

## THE NATURE OF CONTROL BY SPOKEN WORDS OVER VISUAL STIMULUS SELECTION<sup>1</sup>

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Eight retarded adolescents were trained to select one (a trained S+) of two visual stimuli in response to a spoken word (a trained word). Two different visual stimuli alternated randomly as the S-. To determine if the spoken word was merely a temporal discriminative stimulus for when to respond, or if it also specified which visual stimulus to select, the subjects were given intermittent presentations of untrained (novel) spoken words. All subjects consistently selected the trained S+ in response to the trained spoken word and selected the previous S- in response to the untrained spoken words. It was hypothesized that the subjects were responding away from the trained S+ in response to untrained spoken words, and control by untrained spoken words would not be observed when the trained S+ was not present. The two visual S- stimuli selected on trials of untrained spoken words were presented simultaneously. The untrained spoken words presented on these trials no longer controlled stimulus selections for seven subjects. The results supported the hypothesis that previous control by spoken words was due to responding away from the trained S+ in response to untrained spoken words.

*Key words:* stimulus control, attention, acquisition, discrimination, retarded adolescents

Vincent-Smith, Bricker, and Bricker (1974) suggested that toddler-aged children, (20 to 31 months) acquire new receptive vocabularies for unknown objects more rapidly when the S- in a two-choice task is a known object than when both the S- and the S+ are unknown. The 14 subjects were given 20 trials per daily session in which 10 trials contained a known object as S- (e.g., truck) and an unknown S+ (e.g., spatula) and 10 trials contained unknown objects as both the S+ and S-. The experimenter instructed the child to "give me (name of S+ object)". These two types of problems were presented for five sessions. The group mean performance on the known S- problems was significantly higher than chance (0.50) in each of the five sessions. The investigators suggested that the high level of accuracy could be due to the subjects responding away from the known S- objects in response to an unknown spoken word. The group performance on unknown S- trials was near the chance level in

the initial session. However, by the fifth session the subjects were performing correctly on nearly all problems.

While young, normal children may rapidly acquire vocabulary, language-delayed or retarded persons often do not. In addition, it can be extremely time consuming to train such a person to select one choice object or picture in response to one spoken word and to select another choice in response to another spoken word. A three-step training sequence is widely used in applied research and practical settings for training choice selection conditional on a specific spoken word or a specific grammatical form, e.g., singular *versus* plural nouns, Guess (1969), Guess and Baer (1973). In Step 1, the subject is typically rewarded for selecting one of two stimulus choices in response to the corresponding spoken word until criterion performance is attained. In Step 2, the spoken word corresponding to the second stimulus choice is presented and the subject is now rewarded for selecting the previously incorrect stimulus choice until criterion performance is again attained. In Step 3, the two spoken words are presented in a random sequence across trials and reinforcers are delivered contingent on selection of the corresponding stimulus choice. After meeting criterion on Step 1, it is common to find an error on at least the first

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trial of Step 2, and Step 3 typically requires the greatest number of trials to criterion. The important relationship between the three-step training sequence and the Vincent-Smith *et al.* (1974) study is in the first trial of Step 2. We may hypothesize that if the Step 1 training had established control by the spoken word over the choice selection that it would constitute a known choice in the Vincent-Smith *et al.* terminology. In Step 2, the trained choice functions as the S- for an unknown or untrained S+. Responding away from the trained choice in response to an untrained spoken word in Step 2 may then become at least one measure of established control by the trained spoken word over the trained choice selection in Step 1 of training.

Terms such as inhibition and avoidance appear inappropriate for responding away from a stimulus immediately after a history of reinforcement for responding to that stimulus. The term "exclusion" is used in this study to refer to the responding away from or excluding the stimulus choice trained in the presence of one spoken word to select the untrained stimulus choice in the presence of an untrained spoken word.

In the present study, the exclusion of a trained choice and selection of the untrained choice in response to an untrained spoken word was used as an indication of control by spoken words over the visual choice selection. Eight subjects of borderline and mild levels of retardation were trained to respond to a visual symbol designated at S+, the trained choice, in a two-choice task in response to the appropriate spoken word. The subjects were not permitted to select a stimulus choice until the experimenter had presented the appropriate spoken word. Two different stimuli varied as S-. The stimuli consisted of Japanese and Greek symbols with the corresponding spoken words. Once a subject met criterion on responding to the trained choice in response to the spoken word (hereafter called a trained trial) a technique for probing the controlling relations between the trained spoken word and responding to the trained choice was introduced. (See Sidman, 1960 for a discussion of probing techniques.) The probing procedures were designed to determine if the nature of control by the trained spoken word was restricted to a temporal discriminative stimulus for when to select the trained visual choice or

if the trained spoken word also functioned as a discriminative stimulus for the specific visual stimulus selection. Step 2 consisted of continued presentations of trained trials, plus randomly interspersed trials (probes) on which the untrained spoken word was presented and responses to the untrained choice were reinforced while the trained choice became the S-. These trials are referred to as "exclusion probes". Choice selection on the exclusion probes may then be compared to choice selection on the trained trials. A subject who selects the untrained stimulus choice in response to untrained spoken words is demonstrating discriminative control by spoken words that extends beyond the temporal relationship required during training.

If a subject responds to the trained choice on trained trials and to the untrained choice on the exclusion probes, it is conceivable that responding could be controlled by prior association of the untrained spoken word and untrained visual choice. A subject who appropriately selects the untrained choice on the basis of excluding the trained choice in response to an untrained spoken word should not demonstrate control by the two untrained spoken words when the trained choice is not present as the S-. The two stimuli, which varied as the untrained choice in training and which were presented on an equal number of exclusion probes, were presented simultaneously as the two choices on an additional set of probes, called discrimination probes. The purpose of the discrimination probes was to determine if appropriate selection of the untrained choice stimuli would be maintained when the trained choice was not available for correct responding on the basis of exclusion.

## METHOD

### *Subjects and Experimental Setting*

Eight residents of the Parsons State Hospital and Training Center participated. Based on performance on a battery of intelligence tests listed in each child's hospital records, all subjects were classed as borderline or mildly retarded (approximate IQ of 55 or higher). The ages of the subjects ranged from 13 to 20 yr.

Each child was seen individually in a small room containing a table, two chairs, the experimental stimuli, and tokens that were exchanged in a reinforcer store after each session.

The room also contained a one-way window on one wall.

The experimental sessions were conducted once each day five days per week. The initial testing sessions consisted of 12 trials each. Training sessions consisted of 18 trials. Sessions in which exclusion and discrimination probe trials were presented contained a total of 22 and 26 trials respectively. These totals reflect retention test trials as well as an 18-trial experimental sequence for the probe trial sessions. The duration of the experiment for each subject ranged from three to five weeks.

### Experimental Stimuli

Figure 1 presents all experimental stimuli used in the study. Two sets of stimuli were composed of Greek letters and one set contained Japanese symbols. Within each set of stimuli the spoken words consisted of a one-syllable, a two-syllable, and a three-syllable word to assist in making the auditory discriminations as simple as possible. Figure 1 shows the spoken word and visual symbol selected for the S+ in training within each set of stimuli.

### General Experimental Design

The experimental procedures were replicated across three sets of stimuli for each subject. Initially, all sets of stimuli were pretested at least twice in a counterbalanced order across subjects. For each child, one set of stimuli was

selected for training and subsequent probing. The remaining two sets were then retested and a second was selected for training and probing. The third set was again retested. If the child had not acquired the appropriate responses to the spoken words, the training and probing procedures were presented.

### Initial Test and Subject Screening Conditions

The purpose of pretesting the experimental stimuli was to screen out potential subjects who could rapidly acquire word-referent associations under the test conditions. Each of the three sets of stimuli was individually tested. Each test consisted of 12, two-choice trials in which each of the three stimuli within the stimulus set was presented as the S+ on four trials and as the S- on four trials. The left-right positioning of the S+ stimuli was controlled in each test. Tokens and verbal praise were contingent on each correct response.

Each test was presented at least twice. The order of test presentations for the three sets of stimuli is indicated by the letters A to F for each subject with the results in Figure 5. Potential subjects who scored 75% correct or better on at least two of the three tests on both presentations of the test were not included in the study. In addition, subjects who showed an average overall change in performance from the first to the second testing session of  $\pm$  two responses were given a third assessment. If the subject again showed an overall change in performance from the second to the third set of tests, the subject was not included in the study. Four children were excluded from the remainder of the study as a result of the assessment procedure.

### Procedures

The order of presenting the sets of stimuli for training and subsequent probing was generally counterbalanced across subjects. An individual subject's pretest scores were also taken into consideration. When pretest scores across the three sets of stimuli varied, the set where performance was nearer chance level was typically presented first.

**Training:** one stimulus from a set was selected as S+ choice (trained choice) and the two remaining stimuli varied as the S- choice. Figure 2 illustrates a few trials from a training session. Using the "pi", "theta", "upsilon" set

## Experimental Stimuli

Set 1	<div> <div>PI</div> <div>Π</div> </div>	<div> <div>Theta</div> <div>Θ</div> </div>	<div> <div>Upsilon</div> <div>Υ</div> </div>
Set 2	<div> <div>No</div> <div>子</div> </div>	<div> <div>Chichi</div> <div>父</div> </div>	<div> <div>Kotoba</div> <div>言</div> </div>
Set 3	<div> <div>Phi (Fee)</div> <div>Φ</div> </div>	<div> <div>Gamma</div> <div>Γ</div> </div>	<div> <div>Omega</div> <div>Ω</div> </div>

☐ trained

Fig. 1. Experimental stimuli.

### Training Session

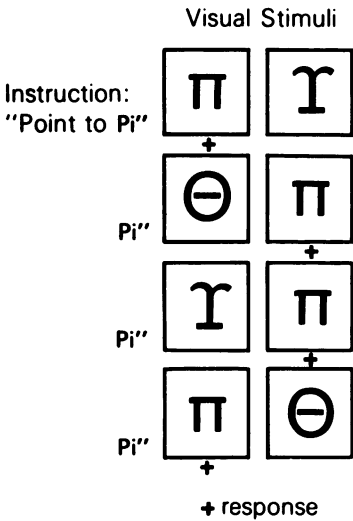


Fig. 2. Exemplar stimuli from the training condition.

of stimuli as an example, the experimenter presented the visual choices and instructed the child to "point to pi". On the first trial of the first training session, the experimenter pointed to the S+ choice and said, "This is pi. You point to pi." No further demonstrations were given. The initial or carrier phrase of the instruction was often varied within the session to "show me", "where's", or "find". When necessary, the experimenter also instructed that hands be kept in the child's lap until spoken instruction was presented.

Praise and a token were given for each correct response. Criterion for completing training was 16 of 18 correct responses or better for one session.

*Exclusion probes:* six probe trials, three with *theta* and three with *upsilon* as the correct choice and *pi* as the S-, were interspersed among 12 trained trials. Figure 3 illustrates a few trials from an exclusion probe session. On the probe trials, the visual choices were identical to those used on trained trials, but the experimenter changed the verbal instructions to "point to theta" or "point to epsilon". The placement of the probe trials within the trained trials was different for each set of stimuli. For the stimuli shown as Set 1 in Figure 1, the probes were presented on trials 3, 6, 9, 11, 12, and 16. For Set 2, the probes occurred on trials 2, 4, 8, 12, 15, and 17, and for Set 3, on trials 1, 4, 7, 10, 15, and 16. All correct re-

### Exclusion Probe Session

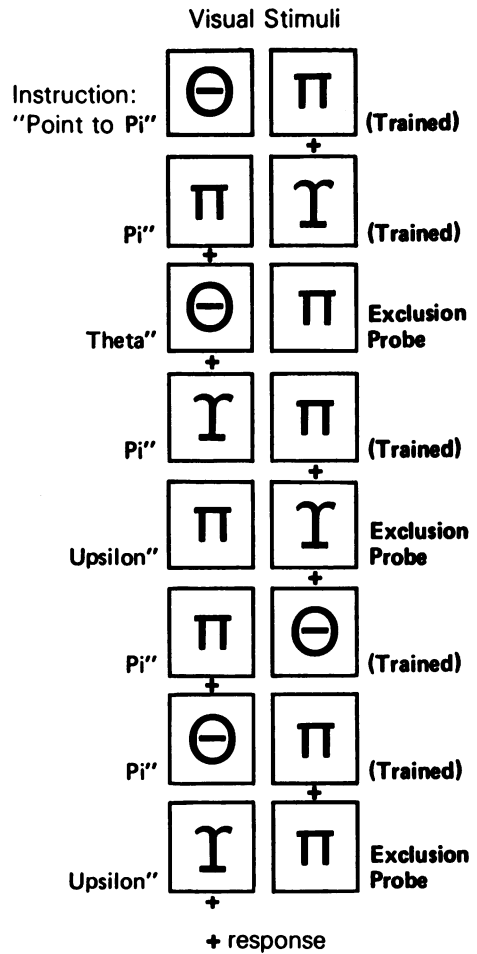


Fig. 3. Exemplar stimuli from the exclusion probe condition.

sponses on the trained trials and on the probes were reinforced with a token and verbal praise.

At the beginning of each probe session, the subject was given four trained trials to assess retention of selecting the trained choice in response to the trained spoken word. If one error occurred on a retention trial, an additional four trained trials were given. If another error occurred, the subject was given an additional 18 trained items and was again required to meet training criterion before the probes were presented. None of the subjects made more than one error on the retention trials.

*Discrimination probes:* it is conceivable that selection of the untrained choice in the pres-

ence of the untrained label on the exclusion probes was controlled by a rule such as, "if the spoken word is *pi* select the trained choice; if the spoken word is not *pi* select the untrained choice". Any rule of this nature would suggest that the untrained spoken words, *e.g.*, *theta* and *upsilon* would not control selection of the respective symbols when the trained choice symbol, *pi* was not available. To test such a possibility, the two untrained choices, *e.g.*, *theta* and *upsilon* were presented as the two simultaneous choices on the discrimination probes. Figure 4 illustrates a few trials from a discrimination probe session. On three

of the six discrimination probes the experimenter said, "point to upsilon" and on the other three probes she said, "point to theta". The probes were again interspersed among 12 trained trials, as shown in Figure 4. For stimuli in Set 1, the probes were presented on trials 2, 4, 7, 12, 14, and 18; in Set 2, on trials 1, 4, 6, 9, 11, and 15; in Set 3, on trials 2, 6, 8, 10, 13, and 16.

At the beginning of each session of discrimination probes, four trained trials were presented to assess retention of the trained choice. The same criterion for retention was used as in the exclusion probe sessions. In addition, two exclusion probes were also presented immediately before and after the 18-trial sequence of discrimination probes and trained trials. The purpose of presenting the exclusion probes before the 18-trial sequence including discrimination probes was to check for retention of appropriate responding to each of the untrained choice when the trained choice was still available. The discrimination probe sessions were continued until the subject scored 100% correct on the probe items or until four sessions of probes had been presented without reaching the accuracy criterion.

### Reliability

Dependent variable reliability was obtained by having an observer record the subject's responses along with the experimenter. The observations were made from the adjoining observation room on three different occasions for each of the four conditions of the study (pre-testing, training, exclusion probes, discrimination probes). Each subject was observed at least once for the reliability measures across the four experimental conditions. Agreement between the observer and the experimenter was always 100%.

Reliability of the experimenter in following the designated procedures was collected by two observers on three different occasions for each phase of the study. Both observers were sophisticated in their knowledge of the procedures. For each trial, the observers followed a check list that included checking that (1) the appropriate spoken instructions and visual stimuli were presented, (2) the experimenter provided no additional observable cues to indicate which choice was correct (this aspect was particularly watched on probe trials), and (3) consequences appropriate for the subject's response were de-

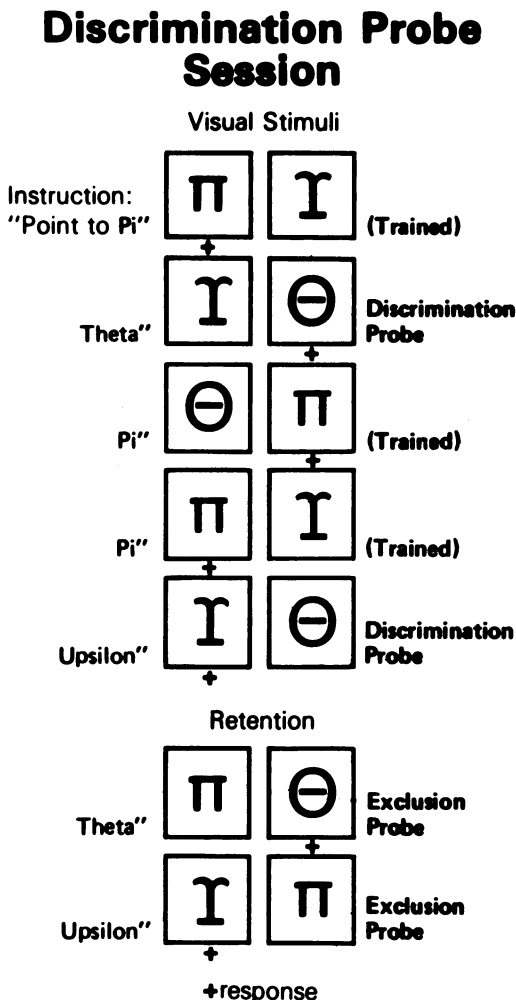


Fig. 4. Exemplar stimuli from the discrimination probe condition. Subjects were given four retention trials for the trained item and two retention trials of the exclusion probes before the discrimination probe sequence. Two additional exclusion probes immediately followed the discrimination sequence.

livered. The two observers agreed that the experimenter made one error by failing to provide tangible reinforcement for one correct response in a training session. All other behaviors were checked as correctly following the procedures described.

## RESULTS

The data of the individual subjects are presented in Figure 5. The bar graphs in Figure 5 present data only for the probe trials. Acquisition of selecting the trained choice was extremely rapid, as seven of the eight subjects met criterion in the first training session of each set presented. More important, within the first exclusion probe session of each set of stimuli, every subject selected the untrained choice on each presentation of an untrained spoken word while continuing to respond correctly to the trained spoken word. With only one exception, the subjects scored 100% correct on selecting the trained choice in response to the trained spoken word within the exclusion probe session. Subject PH did make one error on a trained trial in the first set of exclusion probes presented.

Performances on the exclusion probe trials given immediately before and after each discrimination probe session were 100% correct for every subject on every set of stimuli presented. (These retention data are not presented in Figure 5.) All subjects maintained 100% correct responding on all trained trials. Although the subjects continued to identify the untrained choices when the alternative was the trained choice (the exclusion probes), they generally failed to identify the untrained choices when they were presented simultaneously on the discrimination probes. On the first set of stimuli presented, six of the eight subjects never acquired the discrimination within the four-session limit. Subject TK was the only one to demonstrate immediate control by spoken words for the untrained choices on the first set of stimuli presented. Analysis of TK's specific responses on the Japanese pretest indicated that the specific word-referent associations on the discrimination probes had not been acquired during the pretest condition. No errors occurred on any of the trained trials or exclusion probes.

On the second set of stimuli presented, two of the eight subjects still failed to reach 100%

accuracy on the discrimination probes within four sessions. On the final set of stimuli, six subjects scored too high on the pretest to replicate the procedures a third time. The procedures were replicated with two subjects, PH and KT, as their pretest scores on the third set were quite variable. Both subjects were 100% correct on the first session of each experimental condition.

## DISCUSSION

The subjects were trained to select one of two choice stimuli in the presence of one spoken word. Their acquisition may appear unusually rapid if compared to the time necessary to establish S+ control with nonhuman species. However, the initial demonstration of the S+ or trained choice by the experimenter (*i.e.*, "This is pi. You point to pi."), in addition to the reinforcement contingencies, is typically an efficient procedure for establishing consistent responding to one of two choice stimuli with subjects classed at the higher levels of retardation.

During the training condition, subjects were required to refrain from selecting a visual choice until the spoken word was presented. A temporal relationship between the complete spoken phrase and choice responding was therefore established. The spoken phrase was at least a discriminative stimulus for when to respond. The exclusion probes were inserted to provide an indication of control by the spoken words as discriminative stimuli for what to respond to in addition to when to make the choice selection response. All subjects in the present study systematically selected the untrained choice in response to an untrained spoken word (the exclusion probes) and selected the trained choice in response to the trained spoken word (trained trials). Such performance suggests that an association between the trained spoken word and trained visual choice had been established.

Since the spoken words within each set of stimuli were selected to make the auditory discriminations as simple as possible, any of a number of dimensions within the spoken words could potentially be the controlling variable. While it is possible for a subject to abstract a rule based on components of the words for any one set of stimuli, it is difficult to see how any one component rule would apply to all three

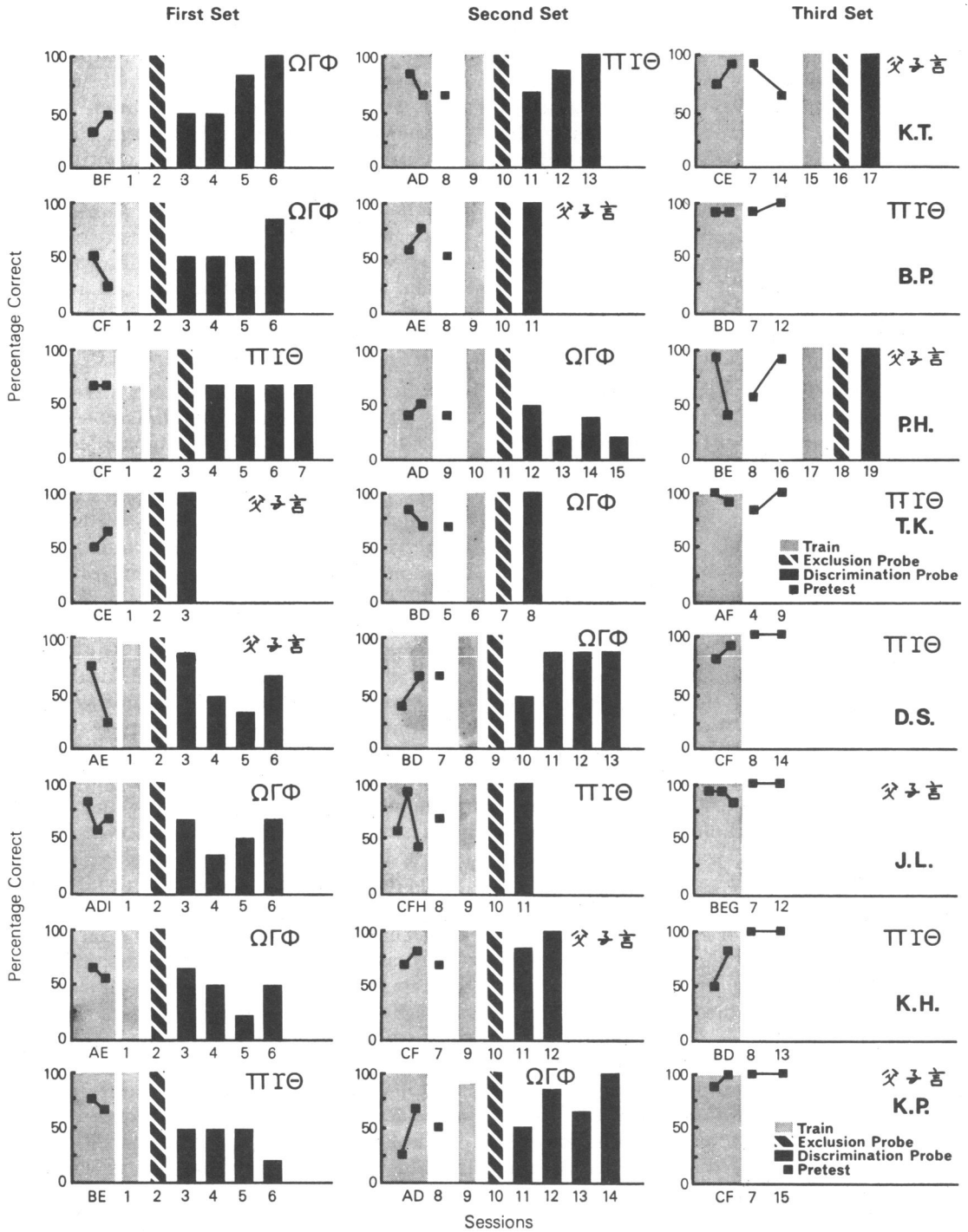


Fig. 5. The initial pretesting and screening results are identified with a shaded background. The letters A through F below the shaded areas indicate, in alphabetical order, the sequence in which the three sets of stimuli were presented to each subject. A indicates the first test presented; B the second, etc. The numerical order of sessions begins with the first training session and indicates the session sequence for all sessions after the initial tests. The data for the exclusion and discrimination probe sessions represent only the six probe trials.

sets of stimuli. For example, with the *pi*, *theta*, *upsilon* stimuli, a subject could be under control of word length with a rule such as, "if I hear a little word (*pi*), respond to the trained choice, if not a little word (*theta* or *upsilon*) respond to the untrained choice". Since the length of the trained spoken word was different for each set of stimuli, a subject would have to formulate a new rule for each set and the basis for formulating the rule would not be available until the exclusion probes were presented.

In addition to controls provided by using different sets of stimuli, the subjects provided anecdotal evidence that they had attended to the complete characteristics of at least some of the spoken words. The subjects occasionally imitated the spoken word before making the choice response or they would point to a symbol and say, "That's (*pi*).". The word "chi chi" was also noted in the spontaneous speech of three subjects, e.g., "I like those chi chi ones," "Can we do chi chi this time?," "Chi chi's silly." The verbal imitation provides detailed evidence of auditory discrimination, and the choice responding on the exclusion probes relative to the trained trials provides evidence of association between trained spoken word and trained choice.

The exclusion probe performance across all sets of stimuli could be based on a rule such as, "if the trained spoken word is presented, respond to the trained choice, if not the trained spoken word, respond away from the trained choice". If the nature of control by the spoken words was based on exclusion of the trained choice in the presence of an untrained spoken word, then control by the untrained spoken words should not be observed when the basis for exclusion (the trained choice) has been removed.

On the discrimination probes, subjects were given the two untrained choice stimuli to determine if control by the spoken words would be demonstrated when a discrimination between the two untrained spoken words and choices was required for accurate responding. On the discrimination probes in the initial session of the first set of stimuli presented, seven of eight subjects did not demonstrate control by the spoken words. Such performance strongly supports the notion that the nature of auditory control over choice responding was based on the exclusion of the trained choice

in the presence of a spoken word that was "not the trained spoken word".

To some extent, it is difficult to explain the continued lack of control by spoken words across sessions on the discrimination probes. On the first set of stimuli presented, six subjects had not acquired the discrimination after four sessions of six probes each. The same subjects demonstrated rapid acquisition of the trained choice and sufficient control by the spoken words to change choice selection as the spoken word changed from trained trials to exclusion probes.

One possible explanation of slow acquisition on the discrimination probes is that the visual stimuli presented on the probes were previously given the common function as S— for the trained choice. In addition, the subjects may have treated the corresponding spoken words as "not the trained spoken word", resulting in a common function of the spoken words as well as the visual choices. It is conceivable that the common functions of the visual and/or spoken stimuli established an equivalence between the stimuli, at least within the context of the experimental procedures. Such an equivalence could subsequently interfere with discrimination between the equivalent stimuli as on the discrimination probes. A recent study on functional equivalence of stimuli (Spradlin and M. Dixon, 1976) suggests that stimuli that have a common function, as defined by the contingencies of reinforcement, may become equivalent, at least within similar contexts.

The discrimination probe data also illustrate the problem of training retarded persons to select choices explicitly conditional on spoken words, as described in the introduction. The subjects in the present study were all classed as borderline or mild in level of retardation, and their verbal behavior was sufficient to permit extensive conversations with the experimenter on topics such as the Special Olympics, teenage movie stars, and their current romances.

The three-step sequence described in the introduction, frequently used for training retarded persons to select choices explicitly conditional on spoken words, is based on the laboratory procedures used in a series of studies by Gollin (Gollin, 1964; Gollin, 1965; Gollin and Liss, 1962) to train young normal children to select visual choices conditional on the visual background configurations. Gollin's procedures were similar to those used by Lash-



ley (1938) to study conditional reactions in the rat. In Lashley's study, the subjects were initially taught to select one of two triangles differing in orientation, shown against a black background. When a criterion of accurate performance was reached, the two triangles were shown against a background of black and white horizontal striped lines. Subjects were now rewarded for selecting the second and previously incorrect triangle with a different orientation. When criterion performance was again established, the subjects were returned to the first discrimination with a black background. The alternate training to criterion with the two backgrounds was continued until the subject demonstrated immediate changes in choice selection with changes in the background. Lashley then presented four additional tasks to determine if a variety of such problems would lead to a generalization that he described as "any stimulus which is correct in situation A is incorrect in situation B". The generalization was not observed.

The young, normal children, 3.5 to 6 yr of age, in the Gollin and Liss (1962) study did not immediately change choice selections with the first trial in Step 2, where they were given a change in background configuration. In Step 3, the two background configurations varied from trial to trial in a random order. The majority of the youngest children did not meet criterion on Step 3 within the 50-trial limit. While the older children did acquire the discrimination in Step 3, they required more trials to reach criterion than in either Step 1 or Step 2.

In contrast, the subjects in the present study were trained to select one visual stimulus in response to one spoken word, and on the exclusion probes the subjects subsequently selected another visual stimulus in response to a different spoken word. The abstraction demonstrated by the subjects might be verbalized as "any stimulus that is correct for spoken word A is incorrect for a different spoken word".

The established, functional repertoire of verbal behavior may be an important variable in the present results. Additional data collected in our laboratory suggest that nonverbal persons and even persons with limited expressive verbal behavior will not exclude a trained choice in response to an untrained spoken word. The control by spoken words that was observed on the exclusion probes in the pres-

ent study may be based on a previously established and generalized rule on abstraction of a relationship between spoken words and environmental events.

While spoken words are no different from other types of stimuli with respect to the principles of behavior, the subjects participating in this study had a long environmental history with spoken words functioning as discriminative stimuli controlling their behavior, as well as producing spoken words to control the behavior of other persons. While other classes of stimuli, such as pure tones or colored lights, may set the occasion for specific events in the natural environment, there is no general rule that describes an environmental relationship across such a broad a range as words, spoken or written, and their associated referents. Had pure tones, rhythmic sound patterns, visual lights, or visual differences in the background configurations of the choice stimuli been used rather than spoken words, it is doubtful that the same subjects would have responded away from the trained choice on the exclusion probes.

Research by Warren (1960, 1964) also suggests that prior experimental history may be important in establishing control over choice selection. Warren's experimental paradigm used in training rhesus monkeys was vastly different from that used by Lashley (1938) or in the Gollin studies. However, in one study the monkeys had been previously "trained on 90 conditional discrimination and discrimination reversal problems" (Warren, 1964). Warren reported that the monkeys made fewer errors in reaching criterion on the conditional discrimination problems than the children 5.5 to 6 yr of age in the Gollin and Liss (1962) study. He attributed the superior performance of the monkeys to both the difference in training procedures and the experimental sophistication of the monkeys.

The present study provides evidence of generalized control by spoken words over the visual choice selection of borderline and mildly retarded persons. An important area for future research will be to determine the necessary and sufficient conditions for such control.

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